WPS0799

Policy Research

WORKING PAPERS

International Trade

International Economics Department
The World Bank
October 1991
WPS 798

Agriculture's Decline in Indonesia

Supply or Demand Determined ?

Will Martin
and
Peter G. Warr

Capital accumulation and rapid technical change in agriculture are each found to contribute much more to the decline in agriculture's share of GDP than do the relative price effects typically emphasized in the literature on agriculture's decline. From the results, increased attention to supply-side influences on the process of structural transformation appears warranted.

Public Disclosure Authorized

Policy Research

WORKING PAPERS

International Trade

WPS 798

This paper — a product of the International Trade Division, International Economics Department — is part of a larger effort in the Bank to analyze the process of growth and transformation in developing countries. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Maria-Theresa Sanchez, room S7-075, extension 33731 (19 pages). October 1991.

Agriculture's share in an economy invariably declines as per capita income rises and as the economy develops. This relative decline in growing economies is a central feature of economic development and a major influence on agricultural policies. The literature on its causes has focused on the relative price effects arising from demand factors — especially Engel's Law (that the proportion of income spent on food declines as incomes rise) — rather than on such supply-side influences as changes in relative factor endowments and different rates of technical change.

Engel's Law is convincing at the global level but it does not explain why agriculture's share should decline sharply in small open economies that experience rapid economic growth. A small open economy that grows rapidly need not reduce agriculture's share in production. Instead, it could increase its exports of agricultural products as food becomes less important in domestic consumption.

Martin and Warr develop a simple structural model of the transformation of the Indonesian economy, applying the Error Correction Mechanism to capture the dynamics resulting from disequilibria and costs of adjustment. They develop an econometric model of the economy's supply side so they can explain agriculture's decline by the three theoretical factors: relative price changes, technical change, and factor accumulation.

Based on the model's results, they conclude that the decline in the relative price of agricultural output contributed relatively little to the decline in agriculture's share. Technical change actually had a positive effect on agriculture's share, retarding the pressures for a decline in its share over time. By far the most important influence appears to have been the rapid accumulation of capital relative to labor over the period studied (1960-87).

These results have important implications for the way economists view the process of structural change under economic development. The emphasis has been on demand-side factors. Supply-side factors may be far more important than economists have believed them to be.

Explaining Agriculture's Relative Decline: A Supply Side Analysis for Indonesia

by
Will Martin
and
Peter G. Warr

Table of Contents

Explaining Agriculture's Relative Decline: A Supply Side Analysis for Indonesia

I. Introduction

The relative decline of agriculture as a share of total output is a central feature of economic development. Since 1965, this structural change has proceeded extremely rapidly in Indonesia, despite a highly successful 'green revolution' which has brought increases in agricultural yields and production. Since the economic and political chaos of the early 1960s, Indonesian GDP has increased at an average annual rate of 7 per cent in real terms, or 4.6 per cent per capita. Agricultural output has increased at 4.3 per cent in real terms, but from 1965 to 1988 the share of agriculture in Indonesia's GDP declined from 56 to 24 per cent (World Bank, 1990a).

In this analysis, we characterize the supply side of the economy in terms of an aggregate production possibility frontier describing all potential output combinations of agricultural output (A) and non-agricultural output (N),

$$H(A, N, K, L, R, T) = 0 \tag{1}$$

where K is the total capital stock in the economy, L is the total labor force, R is the natural resource endowment and T is an index of technology. The position and shape of the frontier describing potential output combinations A and N depends on aggregate factor supplies and the technology in each industry. The position on the frontier at which the economy will produce depends on relative commodity prices.

Three potential proximate causes for a decline in the share of agriculture in the course of economic growth can now be discerned:

(i) changing relative prices;
(ii) changing relative factor supplies; and
(iii) differential rates of technical change.

Factor (i) changes the position on the production possibility frontier at which production occurs, while factors (ii) and (iii) directly affect the position and shape of the frontier itself.

The literature on the decline of agriculture has emphasized the first and third of these proximate causes. By far the most attention has been focused on the relatively low income elasticity of demand for food, which, ceteris paribus, causes the relative price of food to decline in a closed economy, or for the world as a whole (Schultz, 1953). Differential rates of technical change have also been considered, with technical change in agriculture frequently assumed to be relatively slow in the developing countries (Chenery, Robinson and Syrquin, 1986:74). While changing relative factor supplies have received a great deal of attention in the trade theory literature (e.g. Rybczynski, 1955; Leamer, 1987), they have received little attention in the literature on agriculture's decline.[1]

The effect that changes in aggregate factor supplies have on the composition of output at given relative commodity prices is known in the international trade theory literature as the Rybczynski effect. Specifically, in a two sector model with relative commodity prices constant and assuming full employment, if the aggregate stock of capital increases relative to the labor supply, the output of the more capital intensive industry must increase - proportionately more than the growth of capital under constant returns to scale - but the output of the more labor intensive industry must decline absolutely.

The decline in the agricultural sector under economic growth has massive economic and social implications, particularly given the adjustment costs and pressures it induces. Governments frequently intervene to influence the rate of this adjustment, typically attempting to increase the rate of decline in the early stages of growth, and to retard it at higher levels of development (Anderson and Hayami, 1986). Price interventions are typically the most important of these measures, but governments are also heavily involved in the development and dissemination of technological innovations. Government policies also typically influence rates of factor accumulation.

---

[1] Anderson (1987) is an exception. In listing the potential causes of agriculture's decline, Anderson mentions the possible relevance of the Rybczynski effect.

Indonesia provides a particularly interesting case for the study of these phenomena. Its agriculture has experienced some major adjustment pressures resulting from relative price changes induced by the 'Dutch Disease' effects of the successive oil booms in the 1970s as well as from world commodity markets (Warr, 1986). Government agricultural policies have also had an important influence on producer prices. In addition, the Indonesian government has invested heavily in infrastructure to facilitate the adoption of improved agricultural varieties.

In the next section of this paper, we outline our methodology. In section III, the data are discussed and the results are presented in Section IV. Finally, our conclusions are summarized in Section V.

II. Methodology

Given our purposes, it is considerably more convenient to represent the aggregate production process (equation 1) in terms of its dual. In particular, we use an aggregate restricted GDP function based on the theoretical models discussed by Dixit and Norman (1980) and estimated by a number of authors including Kohli (1978), and Lawrence (1989). We utilized a Translog functional form for a long-run revenue function in which:

$$(2) \qquad \ln \pi = a_o + \Sigma_i a_i \ln p_i + 1/2\, \Sigma_j \Sigma_i a_{ij} \ln p_i \ln p_j + \Sigma\, b_i \ln F_i + 1/2\, \Sigma_i \Sigma_j b_{ij} \ln F_i \ln F_j + 1/2\, \Sigma_i \Sigma_k c_{ik} \ln p_i \ln F_k$$

where π represents total revenue, the p variables represent prices of agricultural and nonagricultural output (p_A and p_N), the F variables represent quasi-fixed factor inputs (K, L, R and T) and the a_i, a_{ij}, b_i, b_{ij} and c_{ik} terms are fixed coefficients.

In this formulation the K, L and R variables represent the total endowments in the economy rather than sectoral factor allocations. This is an important advantage over approaches requiring data on sectoral allocations because accurate measures of sectoral capital stocks and other factor allocations are frequently difficult to obtain and because the sectoral definitions used to allocate factors may not be appropriate for behavioral analysis. Labor and capital use in food processing, for instance, is likely to be allocated to the service sector even though the demand for those factors responds more directly to the determinants of agricultural output. It seems reasonable to treat the total endowments of K, L and R as pre-determined in this system since factor accumulation is determined in a much broader system involving a wide variety of demo raphic factors, expectations of future returns on capital, and involving significant response lags. There seems little reason to expect correlation between these variables and the residuals of the commodity output share equations. The widely used approach of specifying factor prices as exogenous, e.g. Diewert and Morrison (1988), seems much more likely to introduce such simultaneity problems.

The familiar Translog functional form was chosen primarily because of its analytical properties. Differentiating this function with respect to the log of the price of agricultural output, and invoking Shephard's lemma, yields a simple estimating equation with the output share of sector i of the economy, S_i, as its dependent variable.

$$S_i = a_i + \Sigma_j a_{ij} \ln p_j + \Sigma_k c_{ik} \ln F_k \tag{3}$$

Another advantage of the Translog functional form is that, unlike other popular functional forms, it does not impose input-output separability (Lopez, 1985). Despite the simplicity of equation (3), it summarizes all of the information about the structure of the economy which is relevant for our analysis.

The structural specification used in this study does not attempt to explain the behavior of the relative price of agricultural and non-agricultural output. It focusses on the relative importance of the proximate determinants of the decline in agriculture's share of the economy. A more complete specification involving both the supply and demand side could be formulated, but would involve formidable problems of data and estimation. Our approach is intended both as a first step towards a possible complete, simultaneous equation framework and as a complement to other approaches used to model the transformation processes, such as reduced form equations and input-output based decompositions of the sources of growth (see for example, Chenery, Robinson and Syrquin, 1986). While relative prices are not modeled endogenously, the behavior of this price series over time reflects all of the factors, such as world price changes and changes in nontraded goods prices, considered in the literature. The actual behavior of the price series, together with the other right hand side variables, can then be used to decompose the observed changes in the share of agriculture.

A potential statistical problem of simultaneous equations bias may arise where shocks to the composition of output are correlated with income shocks and hence with the prices of non-traded goods. This problem seems less likely to be serious in the individual share equation than in the revenue function itself and the problem of simultaneity has been ignored in virtually all applications of duality theory to the estimation of production structures. Significance tests for possible simultaneous equation bias are available (Beggs, 1988) and, if this bias proved to be significant, simultaneous equation estimation could be used to mitigate its effects.

Equation (3) can be thought of as representing the long-run or equilibrium structure of the economy. However, given the existence of substantial adjustment costs involved in reallocating factors between sectors in response to changes in prices, a real world economy will not be in equilibrium at all times.[2] Adjustment costs arise from both foregone output and direct adjustment costs, both of which are likely to rise at an increasing rate with changes in the rate of adjustment. Some rate of adjustment in labor use between industries can, for instance, be achieved at low cost by changing the mix of training undertaken by new entrants to the workforce. Higher rates of labor use adjustment will require displacement of mature workers with higher training costs due both to higher foregone output and higher training costs per year of post-training employment. Similarly, low levels of capital reallocation can be achieved by allocating replacement investment to activities which are expanding. High rates of capital reallocation will involve foregone output due to the early retirement of capital goods in declining sectors and production and installation costs, both of which are likely to increase more than proportionately with the rate of adjustment.

Some means of accounting for the resulting dynamic behavior is required. A non-linear Error Correction Mechanism (ECM) was chosen as a means of dealing with this problem since

---

2 See also Mundlak (1980) on this point. Mundlak's important paper uses a two sector simulation model to address these issues. Our analysis differs by using the dual approach, which is simpler and which allows direct estimation of the relevant parameters, rather than the hypothetical values used by Mundlak.

it can be shown to be consistent with long-run optimizing behavior in the presence of quadratically increasing costs of adjustment and quadratic costs of being out of equilibrium (Nickell, 1985; Granger, 1986; Gregory, Pagan and Smith, 1990). The particular form of the ECM used in this paper is relatively parsimonious and yet encompasses several well-known dynamic specifications: the autoregressive model, the distributed lag model, and the partial adjustment model (Murphy, et.al., 1986, p. 19).

Most aggregate time series variables of the type used in this study appear to be "integrated" variables which "drift" over time without any apparent tendency to return to a constant long-run mean value (Nelson and Plosser, 1982). When such integrated variables are related by a stable cointegrating vector of coefficients, the long-run relationship between the variables is given bv these coefficients. Both the long-run cointegrating vector and the parameters of the transient dynamics about the cointegrating vector can be estimated using a non-linear ECM (Stock, 1987). This estimator of the cointegrating vector converges relatively rapidly and, while some degree of downward bias may occur in small samples, this problem appears to be much less severe than with the conventional OLS estimator (Stock, 1987; Phillips and Hansen, 1990, p. 119).

Alternative, more sophisticated estimators such as the "fully-modified" estimator of Phillips and Hansen (1990, p. 112) might be used to obtain improved estimates if it is known that the explanatory variables have unit roots (Gregory, Pagan and Smith, 1990, p. 14). However, from the Monte Carlo results reported by Phillips and Hansen (1990, pp. 116-9), the gains from this non-parametric approach seem likely to be slight, particularly if there is limited correlation between the innovations to the right hand side variables and the errors in the cointegrating relationship. If the maintained hypothesis of a unit root which is imposed using the Phillips/Hansen estimator does not hold exactly, this advantage may be even smaller. Further, the non-parametric approach does not provide estimates of the parameters representing short-run dynamic behavior--parameters which are of considerable interest.

An emerging "revisionist" view questions the now widely held belief that most aggregate economic time series are integrated series characterized by a unit coefficient on their own lagged value. The standard tests used to test for the presence of unit roots are based on the null hypothesis that a unit root exists. From recent analysis, it appears that these tests have low power and frequently fail to reject the null hypothesis even when it is not correct (Kwiatkowski, Phillips and Schmidt, 1990). The uncertainty about our ability to identify whether the data are characterized by a precise unit root weakens the case for the use of estimators such as the Phillips/Hansen modified estimators which impose a unit root rather than those such as the ECM which seem likely to be relatively robust to the presence or absence of a unit root.

The basic statistical approach used in this study has four stages: (i) test the data series for non-stationarity; (ii) test for the existence of a long-run or cointegrating relationship between the variables of interest; (iii) fit Error Correction models to allow inferences about both the short-run dynamics and long-run equilibrium relationships; and (iv) assess the resulting models against both economic and statistical criteria (Beggs, 1988).

III. Data

The data series used in the analysis were drawn primarily from the World Bank's World Tables (World Bank, 1990b), supplemented by information from Indonesian sources. The full sample period was 1960 to 1987. On the output side, sectoral value, quantity and price estimates were derived from the World Bank's estimates of output values at current and constant prices, after removing the essentially enclave mining (largely oil) sector using estimates from the World Bank's National Accounts data tapes and recent estimates from the Indonesian Statistical Bureau (Biro Pusat Statistik).

On the input side, an initial value for the capital stock was derived using a trend estimate of gross investment in the first sample period, and assuming that capital and trend investment were in their steady state relationship at that time; i.e., that $\bar{I} = (g+\delta)\bar{K}$, where $\bar{I}$ is the steady state level of investment, g is the rate of growth of real investment (and capital), δ is the rate of depreciation and $\bar{K}$ is the steady state capital stock. The opening capital stock in each subsequent period was updated recursively by adding investment during the previous period and deducting depreciation at an assumed rate of 5 percent per annum.[3] Data on the total labor force were obtained from World Bank (1989).

Two variables were used to capture a possible sectoral bias of technological change between agriculture and other sectors of the economy. The first was a conventional time trend of the type used in most cost or profit function-based studies of technology. The second, reflecting the importance of the adoption of "green revolution" technology in Indonesian crop production, was an index of the adoption of technological change in the Indonesian rice industry using data from Booth (1988) covering participation in government programs to encourage and finance the adoption of this technology. The time trend variable in this equation allows us to capture any bias in technical change resulting from consistently higher rates of productivity growth in the agricultural or non-agricultural sectors. The "green revolution" variable is intended to account for the particular profile of agricultural productivity growth resulting from the introduction of improved rice varieties. Unfortunately, no similar indicator for technical change in the non-agricultural sector was available.

Our index incorporates the proportion of crop area covered by the Bimas (mass guidance) and Insus research and extension programs involving subsidized inputs and credit. Almost all technical change in Indonesian crop agriculture is believed to have been associated with these two programs. Insus is a component of the Bimas program but is more intensive and places considerably more emphasis on the critical issue of pest control (Booth, 1988). In constructing our index, we therefore placed a premium on that part of the Bimas program covered by Insus. Our index is thus $T_a = B + 0.5\ I$, where T_a is our index of the adoption of modern agricultural technology, B is the proportion of total crop area covered by Bimas and I is that proportion of the Bimas program area also covered by Insus.[4]

---

3 Estimates of capital depreciation are difficult to obtain. This value was selected on the basis of official estimates for Thailand reported in Limskul (1988). Some experimentation with alternative rates of depreciation was undertaken, but the results of the analysis did not prove to be sensitive to this parameter over a reasonable range.

4 See Booth (1988) for further discussion of these issues. The authors are grateful to Professor Anne Booth for her kind assistance in constructing these series.

IV. Empirical analysis

The specific forms of the estimating equation used in the analysis were derived from equation (3) by: (i) deflating the price of agricultural output by the price of non-agricultural output; and (ii) deflating each of the quasi-fixed inputs of labor (L), capital (K) and resources (R) by the labor input. The restriction introduced by deflating the agricultural price by the non-agricultural price follows from the theoretical requirement (Varian, 1984, p. 44) that any valid profit function must be homogeneous of degree one in prices. The output supply functions and output shares obtained by differentiating the profit function must, therefore, be homogeneous of degree zero in prices. The only constraint on equilibrium behavior imposed by this restriction is an absence of money illusion.

Deflation of all of the factor input variables in the restricted profit function by one arbitrarily chosen factor follows from an assumed homogeneity of degree one of the profit function in quasi-fixed inputs. Even if individual firms have decreasing returns, the assumption of constant returns can still be applied at the economy-wide level since changes in output can be achieved with equi-proportional input changes simply by changing the number of firms.

The imposition of these two restrictions reduces the number of factor endowment variables to two: ln(K/L) and ln(R/L), where the variation in ln(R/L) resulted only from variations in ln(L) because R was assumed constant for lack of better information on the size of the aggregate stock of natural resources. The coefficient on ln(R/L), which captures the effect of increases in the population 'diluting' the available resource base, was insignificant in all specifications attempted and so this variable was dropped, leaving the capital-labor ratio as an explanatory variable. This result is supported by Brander and Dowrick's (1990) conclusion that resource dilution appeared to be a minor influence on growth rates in a large sample of countries.

The hypothesis that all of the data are integrated series was tested to assess whether the variables were non-stationary and hence particular care would be needed in the interpretation of the coefficients and their significance tests. Standard Dickey-Fuller and Augmented Dickey-

Fuller tests (Fuller. 1976) were used to test for first order integration of each series and the test results for each of these variables are presented in Table 1, together with test statistics for the existence of the postulated long-run (or cointegrating) relationship. These tests and all of the econometric analysis were undertaken using the SHAZAM econometric package.

Table 1: Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) test statistics for integration

Variable	DF*	ADF*
S_a	-0.73	-0.19
$\ln (P_a/P_n)$	-1.73	-1.59
$\ln (K/L)$	-0.64	-0.28
$\ln T_a$	-1.88	-1.72
RS_a	-5.57	-3.45

Notes: *Critical values for these tests are approximately -3.0 with larger values, in absolute terms, implying rejection of the null of integration. The variable S_a is the share of agriculture in Indonesian non-mining GDP; P_a/P_n is the price of agricultural relative to non-agricultural output; K/L is the aggregate capital-labor ratio for the Indonesian economy; T_a is the index of the bias in technical change towards Indonesian agriculture; and RS_a is the residual obtained using Cochrane-Orcutt estimates of the long-run relationship.

The DF and ADF tests fail to reject the hypothesis of integration for any of the initial data series (i.e. SA, $\ln (P_a/P_n)$, $\ln T_a$ and $\ln (K/L)$). Given the apparently integrated nature of the variables under study, attention then focused on the existence of a long-run relationship as postulated in equation (3). A variant of the DF and ADF tests was used to test for the existence of a long-run relationship between the variables of interest. This test, proposed by Hansen (1990) as a more powerful alternative to the Engle and Granger (1987) test, applies the Dickey-Fuller and Augmented Dickey-Fuller procedures to the residuals from the Cochrane-Orcutt procedure (RSA) and uses the same critical values as the DF and ADF tests. From the test results presented in Table 1, it is clear that the hypothesis of nonstationarity is rejected, confirming the existence of a long-run relationship between the variables of interest.

The estimating equation was first run using OLS to provide an initial indication of the nature of the relationship between the variables of interest and their dynamic structure. Then, it was run using the Engle-Granger two-step version of the ECM since this linear estimator allows the application of a wide range of diagnostic tests provided within SHAZAM for heteroscedasticity, residual autocorrelation and parameter stability. Finally, a nonlinear version of the ECM was used to obtain direct estimates of the long-run parameters.

The OLS estimating equation was:

(4) $$S_a = a_o + a_1 . \ln (P_a/P_n) + a_2 (\ln K/L) + a_3 \ln T_a + a_4 t$$

where t is a simple time trend.

The Engle-Granger estimator can be viewed as:

(5) $$\Delta S_a = a_1 \Delta \ln(P_a/P_n) + a_2 \Delta \ln(K/L) + a_3 \Delta \ln T_a + a_4 + a_5 e_{t-1}$$

where e_{t-1} is the residual from the OLS equation (4) and Δ in equation (5) is the first difference operator. The a_i terms in equation (5) are influenced by the dynamic behavior of the model and hence should not be viewed as estimates of the long-run parameters. This presents no difficulties since this equation is estimated primarily to assess the consistency of a general ECM form with the behavior of the data, as well as to provide starting values for the non-linear ECM.

After fitting the equation with and without the time trend, the variable t was excluded from the nonlinear ECM on the grounds of insignificance, resulting in the following equation:

(6) $$\Delta S_a = A [a_1 \Delta \ln(P_a/P_n) + a_2 \Delta \ln(K/L) + a_3 \Delta \ln T_a] + B [S_{a,t-1} - a_o - a_1 \ln(P_a/P_n)_{t-1} - a_2 \ln(K/L)_{t-1} - a_3 \ln T_{a,t-1}]$$

where the a_i variables represent the long-run response parameters and A and B respectively represent the rate of adjustment to changes in the exogenous variables and to deviations from equilibrium in the previous period.

The parameter estimates obtained from these three estimating equations are presented in Table 2.

Table 2: Parameter estimates and diagnostic statistics from estimating equations

	OLS	Engle-Granger ECM	Non-linear ECM
a_0	3.65 (15.6)	-	3.94 (7.46)
a_1	0.32 (12.8)	0.28 (14.1)	0.35 (6.75)
a_2	-0.093 (-1.88)	-0.13 (-2.11)	-0.10 (-8.45)
a_3	0.027 (4.10)	0.014 (1.59)	0.018 (2.27)
a_4	-0.0025 (-0.41)	0.0033 (0.49)	-
a_5	-	-0.57 (-2.77)	-
A	-	-	0.79 (7.11)
B			-0.45 (-2.19)
DW	1.27	1.97	2.32
R^2	0.99	0.91	-
Log likelihood	87.9	90.1	90.7
Hetero a/	-	0.08	0.29
RESET b/	-	2.52	-
LM c/ -(1)	-	0.04	-
-(2)	-	0.79	-
B-J d/		0.95	1.96
Wu-Hausman e/		-0.54	

Note: Values in parenthesis are t-statistics.

a/ Breusch-Pagan LM test from a regression of the squared standardized residuals on the predicted values. Distributed as $\chi^2_{(1)}$ with a critical value of 3.84 at the 5 percent level.
b/ Ramsey RESET2 based on the t-test for significance of the squared predicted value when incorporated in the model.
c/ Breusch-Godfrey tests for autocorrelation of order 1 and for order 1 and 2 combined. Distributed as $\chi^2_{(2)}$ and $\chi^2_{(1)}$ with critical values of 3.84 and 5.99 respectively at the 5 percent level.
d/ Bera-Jarque test for normality of the residuals. Distributed as $\chi^2_{(2)}$ with a critical value of 5.99 at the 5 percent level.
e/ Wu-Hausman test for exogeneity of the explanatory variables. Uses the t-statistic for inclusion of the differenced residuals from a regression of $\ln(P_a/P_n)$ on the predetermined instruments $\ln(P_a/P_n)_{t-1}$, $\ln(K/L)$, $\ln(K/L)_{t-1}$ and $\ln T_a$.

While of interest in providing preliminary estimates of the parameters of interest, the OLS equation was clearly not an adequate representation of the long-run relationship of interest. Such a simple equation cannot be expected to capture the dynamics of response, given the existence of response lags and costs of adjustment, although there is a possibility that it might yield reasonable estimates of the long-run relationships because of the more rapid convergence of OLS with integrated variables (Stock, 1987). Not surprisingly, the Durbin-Watson statistic for this equation provided clear evidence of autocorrelation, highlighting the need for a more comprehensive dynamic specification.

The Engle-Granger two step estimator indicates that the dynamic representation provided by the first-order ECM can adequately represent the dynamics of the system. Neither the Durbin-Watson statistic nor the Breusch-Godfrey statistics provide any indication of autocorrelation. The RESET2 test provides no indication that the functional form is inadequate. The Breusch-Pagan heteroscedasticity test provides no indication of heteroscedasticity in the residuals. Recursive Chow tests and CUSUM and CUSUM Squared tests were also conducted and did not indicate parameter instability. The Bera-Jarque test is consistent with the residuals being normally distributed.

Because the production system under study is part of a simultaneous system in which the prices of some non-agricultural goods (especially nontraded goods) are endogenous, there is a need to ensure that the coefficient estimates do not suffer from simultaneous equations bias. To guard against this possibility, a Wu-Hausman test (see Beggs, 1988) was performed by augmenting the Engle-Granger ECM equation with residuals from a first-stage regression using the predetermined variables specified in the footnote to Table 2. The results of this test do not suggest that endogeneity of the price variable results in biased coefficient estimates.

In the final, nonlinear equation, the coefficients on all of the variables have the expected signs and are statistically significant. The own price elasticity of output supply from the agricultural sector is positive at all points in the sample, a necessary condition for the convexity in output prices required before the technology can be inferred from the parameters of the profit function. The own price elasticity of agricultural output, evaluated at the sample mean, is 0.26, quite high relative to most of the estimates of the aggregate elasticity of agricultural output appearing in the literature (e.g. Binswanger, et. al., 1985).

Three conclusions follow from the results presented above. First, increases in the relative price of agricultural output increase the share of agriculture in the Indonesian economy. Secondly, increases in the capital/labor ratio tend to reduce the share of agriculture in the economy, consistent with the Rybczynski effect. Thirdly, technical change appears, overall, to have been biased towards rather than away from the agricultural sector in Indonesia.

Given the focus of this paper, the long-run coefficients obtained in the preferred (non-linear ECM) equation presented in Table 2, were used to perform a disaggregation of the long-run change in the share of agriculture in the Indonesian economy. This decomposition was performed by multiplying the average annual changes in each of the explanatory variables by the relevant coefficient. In this way the annual decline in agriculture's share of the Indonesian economy was decomposed into three sources obtained above: (i) relative commodity price effects; (ii) factor endowment (Rybczynski) effects; and (iii) technical change effects. The resulting decomposition is given in Table 3.

Table 3: Decomposition of the decline in agriculture's share in the Indonesian economy, 1961-87

Variable	Mean Change per year (percent)	Contribution to change in agriculture's share (percent)
Relative price of agricultural output (P_a/P_n)	-0.43	16.7
Capital labor ratio (K/L)	10.1	114.9
Index of technical change in agriculture (T_a)	15.5	-31.6
Share of agricultural output in non-oil GDP (S_a)	-0.86	100.0

The numbers in the first column of Table 3 indicate the average rate of change in each of the variables appearing in the analysis. It can be seen that, over the sample period as a whole, the price of agricultural output relative to the price of nonagricultural output (the agricultural terms of trade) declined by 0.43 percent per year, while the capital/labor ratio rose by just over 10 percent per year. The intensification variable used as an indicator of the bias in technical change towards agriculture, grew at over 15 percent per year on average, while the share of agriculture in the economy declined at 0.86 percent per year. From these results, it appears that the declining relative price of agricultural output, the influence which has received the vast majority of attention in analyses of this question, has been a relatively minor determinant of the decline of agriculture's share in the Indonesian economy. By contrast, the rapid rise in the capital labor ratio appears to have been far more important. Similarly, the process of technological advance in agriculture represented by our index, appears to have had an important offsetting effect on the rate of decline of agriculture's share in the Indonesian non-oil economy.

This result for Indonesia is consistent with the results of an earlier study for Thailand (Martin and Warr, 1990) and suggests that the process of capital accumulation, via Rybczynski type effects, is an extremely important and hitherto neglected determinant of the crucial and ubiquitous process whereby the share of agriculture declines with economic growth.

V. Summary and conclusions

The theoretical literature on the (relative) decline of the agricultural sector under economic growth allows the potential causes of this decline to be divided into three broad groups involving: declining relative prices; changes in relative factor endowments; and differential rates of technical change.

Drawing on this theoretical specification for the underlying equilibrium relationships, we demonstrated the feasibility of applying the dual approach and the translog functional form, so widely used in microeconomic analyses within agriculture, to the behavior of the Indonesian agricultural sector as a whole. Because of the potentially substantial lags involved in the adjustment process, and because of the apparently nonstationary nature of the data series, a non-linear Error Correction Mechanism was utilized.

If Indonesia is at all typical of developing countries, the results obtained in this analysis appear to require a reorientation of the literature on the declining share of agriculture in the economy. The relative price effects which have been the focus of most of this literature turned out to have limited importance in this context, while the factor accumulation (or Rybczynski) effects which have received scant attention appeared to be overwhelmingly important.

The results also highlight the role that technological change can play in influencing the rate at which the agricultural sector declines. While the literature on structural change frequently assumes that developing country agriculture is technologically stagnant, the results of this study indicate that this need not be the case. In the Indonesian economy, over our sample period, technical change was strongly biased towards the agricultural sector, especially when a specific technical change index reflecting the adoption of improved varieties was adopted.

Clearly, further work will be needed before definitive conclusions can be drawn on the importance of the major determinants of the decline in the share of agriculture. However, we hope that this paper and its results will help to refocus the debate and stimulate the development of new approaches to examination of this economic phenomenon so central to the process of development.

References

Anderson, K., 1987. 'On why agriculture declines with economic growth.' Agricultural Economics 1(3): 195-207.

Anderson, K. and Hayami, Y. (1986) The Political Economy of Agricultural Protection: East Asia in International Perspective, Allen and Unwin.

Beggs, J., 1988. 'On diagnostic testing in applied econometrics.' Economic Record 64(185):81-101.

Binswanger, H., Mundlak, Y., Maw-Cheng Yang and Bowers, A., 1985. Estimation of aggregate supply response from aggregate cross-national data. Division Working Paper No. 1985-3, Commodity Studies and Projections Division, Economic Analysis and Projections Department, Economics and Research Staff, World Bank, Washington, D.C.

Booth, A., 1988. Agricultural Development in Indonesia. Allen and Unwin.

Brander, J and Dowrick, S., 1990. The role of fertility and population in economic growth: new results from aggregate cross-national data; Discussion Paper No 230, Center for Economic Policy Research, Australian National University.

Chenery, H., Robinson, S. and Syrquin, M., 1986. Industrialization and Growth: A Comparative Study. Oxford University Press.

Diewert, E. and Morrison, C., 1988. 'Export supply and import demand functions: a production theory approach' in Feenstra, R., ed., Empirical Methods for International Trade. MIT Press, London.

Dixit, A. and Norman, V., 1980. Theory of International Trade. Cambridge University Press.

Engel, R. and Granger, C., 1987. 'Co-integration and error correction: representation, estimation and testing' Econometrica 55(2):251-76.

Fuller, W., 1976. Introduction to Statistical Time Series. John Wiley, New York.

Granger, C., 1986. 'Developments in the study of cointegrated variables' Oxford Bulletin of Economics and Statistics 48(3): 213-228.

Gregory, A., Pagan, A. and Smith, G., 1990. Estimating linear quadratic models with integrated processes. Working Paper 247, Dept. of Economics, University of Rochester.

Hansen, B., 1990. A powerful, simple test for cointegration using Cochrane-Orcutt. Working Paper No 230, Department of Economics, University of Rochester.

Hendry, D., 1986. 'Econometric modelling with cointegrated variables: an overview' Oxford Bulletin of Economics and Statistics 48(3): 201-12.

Kemp, M.C., 1969. The Pure Theory of International Trade and Investment. Prentice-Hall, Englewood Cliffs, New Jersey.

Kenen, P.B., 1985. The International Economy. Prentice-Hall, Englewood Cliffs, New Jersey.

Kohli, U., 1978. 'A gross national product function and the derived demand for imports and exports' Canadian Journal of Economics XI(2): 167-82.

Kwiatkowski, D. Phillips, P. and Schmidt., P., 1990. 'Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economic time series have a unit root?' Economic and Econometric Theory Paper No. 8905, Dept. of Economics, Michigan State University.

Lawrence D., 1989. 'An aggregator model of Canadian export supply and import demand responsiveness.' Canadian Journal of Economics 22(3): 503-21.

Leamer, E., 1987. 'Paths of development in the three factor n-good general equilibrium model,' Journal of Political Economy 95(5): 961-99.

Limskul, K., 1988. The sectoral capital stock, employment and sources of economic gro' ʻn ı Thailand. International Economic Conflict. Discussion Paper No. 40, Nagoya University.

Lopez, R., 1985. 'Structural implications of a class of flexible functional forms for profit functions' International Economic Review 26(3): 593-601.

Martin, W. and Warr, P., 1990. The declining economic importance of agriculture. Invited Paper presented to the 34th Annual Conference of the Australian Agricultural Economics Society.

Mundlak, Y., 1980. 'Agricultural growth in the context of economic growth,' in Matthews, R. (ed.) Economic Growth and Resources. Vol. 2, MacMillan for the International Economic Association.

Murphy, C., et. al., 1986. A Macroeconomic Model of the Australian Economy for Medium-Term Policy Analysis. Economic Planning Advisory Council, Technical Paper No. 2, Australian Government Publishing Service, Canberra.

Nelson, C. and Plosser, C., 1982. 'Trends and random walks in macroeconomic time series: some evidence and implications.' Journal of Monetary Economics, 10: 139-62.

Nickell, S., 1985. 'Error correction, partial adjustment and all that: an expository note', Oxford Bulletin of Economics and Statistics 47(2): 119-29.

Phillips, P. and Hansen, B., 1990. 'Statistical inference in instrumental variables regression with I (1) processes.' Review of Economics and Statistics. 57(1): 99-125.

Rybcznski, T., 1955. 'Factor endowments and relative commodity prices.' Economica, 22(4).

Schultz, T.W., 1953. The Economic Organization of Agriculture. McGraw-Hill, New Yoık.

Stock, J., 1987. 'Asymptotic propεrties of least squares estimates of cointegrating vectors' Econometrica 55(5): 1035-56.

Varian, H., 1984. Microeconomic Analysis. 2nd. ed., Norton, New York.

Warr, P.G., 1986. 'Indone^sia's other Dutch disease: economic effects of the petroleum boom' in J.P. Neary and S. van Wijnbergen (eds), Natural Resources and the Macroeconomy. MIT Press, Cambridge, Mass.

World Bank, 1989. Social Indicators of Development. World Bank, Washington, D.C.

World Bank, 1990a. World Development Report, 1990. World Bank, Washington, D.C.

World Bank, 1990b. World Tables 1989-90. World Bank, Washington, D.C.

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS771	Macroeconomic Structure and Policy in Zimbabwe: Analysis and Empirical Model (1965-88)	Ibrahim A. Elbadawi Klaus Schmidt-Hebbel	September 1991	S. Jonnakuty 39074
WPS772	Macroeconomic Adjustment to Oil Shocks and Fiscal Reform: Simulations for Zimbabwe, 1988-95	Ibrahim A. Elbadawi Klaus Schmidt-Hebbel	September 1991	S. Jonnakuty 39074
WPS773	Are Ghana's Roads Paying Their Way? Assessing Road Use Cost and User Charges in Ghana	Reuben Gronau	September 1991	J. Francis 35205
WPS774	Agricultural Pricing Systems and Transportation Policy in Africa	Mark Gersovitz	October 1991	B. Gregory 33744
WPS775	The Macroeconomics of Public Sector Deficits: A Synthesis	William Easterly Klaus Schmidt-Hebbel	October 1991	R. Martin 39065
WPS776	Enforcement of Canadian "Unfair" Trade Laws: The Case for Competition Policies as an Antidote for Protection	Mark A. Dutz	October 1991	N. Artis 37947
WPS777	Do the Benefits of Fixed Exchange Rates Outweigh Their Costs? The Franc Zone in Africa	Shantayanan Devarajan Dani Rodrik	October 1991	A. Bhalla 37699
WPS778	A Dynamic Bargaining Model of Sovereign Debt	Eduardo Fernandez-Arias	October 1991	S. King-Watson 31047
WPS779	Special Programme of Research, Development and Research Training in Human Reproduction	Janet Nassim	October 1991	O. Nadora 31019
WPS780	Optimal User Charges and Cost Recovery for Roads in Developing Countries	Ian G. Heggie Vincy Fon	October 1991	P. Cook 33462
WPS781	The Korean Consumer Electronics Industry: Reaction to Antidumping Actions	Taeho Bark	October 1991	N. Artis 37947
WPS782	The Economic Effects of Widespread Application of Antidumping Duties to Import Pricing	Patrick Conway Sumana Dhar	October 1991	N. Artis 37947
WPS783	The Origins and Evolution of Antidumping Regulation	J. Michael Finger	October 1991	N. Artis 37947
WPS784	Chemicals from Poland: A Tempest in a Teacup	Andrzej Olechowski	October 1991	N. Artis 37947

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS785	How Did the Asian Countries Avoid the Debt Crisis?	Ishrat Husain	October 1991	S. King-Watson 31047
WPS786	Fiscal Policy for Managing Indonesia's Environment	Sadiq Ahmed	October 1991	B. Prasertwaree 82477
WPS787	Private Investment Under Macroeconomic Adjustment in Morocco	Klaus Schmidt-Hebbel Tobias Muller	October 1991	S. Jonnakuty 39074
WPS788	How Expectations Affect Reform Dynamics in Developing Countries	Francesco Daveri	October 1991	S. Jonnakuty 39074
WPS789	Intrahousehold Inequality and the Theory of Targeting	Lawrence Haddad Ravi Kanbur	October 1991	J. Sweeney 31021
WPS790	Reforming and Privatizing Hungary's Road Haulage	Esra Bennathan Jeffrey Gutman Louis Thompson	October 1991	B. Gregory 33744
WPS791	Measuring Real Exchange Rate Instability in Developing Countries: Empirical Evidence and Implications	Lant Pritchett	October 1991	K. Cabana 37947
WPS792	Reducing Labor Redundancy in State-Owned Enterprises	Jan Svejnar Katherine Terrell	October 1991	B. Gregory 33744
WPS793	Decollectivization and the Agricultural Transition in Eastern and Central Europe	Karen M. Brooks	October 1991	C. Spooner 30464
WPS794	How Do National Policies Affect Long-Run Growth? A Research Agenda	William Easterly Robert King Ross Levine Sergio Rebelo	October 1991	R. Martin 39065
WPS795	Economic Stagnation, Fixed Factors, and Policy Thresholds	William Easterly	October 1991	R. Martin 39065
WPS796	Excess Liquidity and Monetary Overhangs	Gerard Caprio, Jr. Patrick Honohan	October 1991	W. Pitayatonakarn 37666
WPS797	Using Field Visits to Improve the Quality of Family Planning, Health, and Nutrition Programs: A Supervisor's Manual	Richard Heaver	October 1991	O. Nadora 31091
WPS798	Agriculture's Decline in Indonesia Supply or Demand Determined?	Will Martin Peter G. Warr	October 1991	Maria-Theresa Sanchez 33731